Lyon Inc. -- Detroit, Mich.
Development
of
Deep Drawn - One Piece
High Performance
Rocket Motor Case
Army Cont. DA-20-018-ORD-23004
General Report #11

Copy No. 26

LYON INCORPORATED
DETROIT, MICHIGAN

General Report No. 11
for the period
August 10 through September 10, 1961
on

DEVELOPMENT
OF
DEEP DRAWN - ONE PIECE
HIGH PERFORMANCE
ROCKET MOTOR CASE

Submitted to:

U. S. Army Ordnance
Frankford Arsenal
Technical Supervisor - Mr. C. J. Porembski

INCORPORATED

ORDNANCE PRODUCTS DIVISION

MANUFACTURERS
OF
CARTRIDGE CASES · BOMBS · ROCKET MOTOR CHAMBERS
AND MISSILE COMPONENTS

13881 WEST CHICAGO BOULEVARD

DETROIT 28, MICHIGAN

September 10, 1961

U. S. Army Ordnance
Frankford Arsenal
Philadelphia 37, Pennsylvania

Attention: Mr. C. J. Porembski, Technical Supervisor

Subject: General Report No. 11 on the development of a deep drawn, one-piece high performance rocket motor case

Reference: Contract No. DA-20-018-ORD-23004, Article II -- Reports and Other Data

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This report summarizes the progress made during the period of August 10 through September 10, 1961, to develop improved monolithic rocket motor cases for 40" (and over) diameter solid propellant rockets.

The specific goals are the development of reliable motor cases with hoop-stress limits substantially in excess of 200,000 psi steel equivalent. The motor cases must be capable of being fabricated with reasonable ease on an industrial scale and their producibility proven by reliability tests at final full scale. The general objective is to be accomplished utilizing the Pershing 2nd stage motor case configuration.

I Special Tooling -- Material and Fabrication

(A) 40" Diameter Pershing 2nd Stage Motor Case Dwg. A-1 and A-2

1. Hot Cup Die - No. E-20000

Fabrication of all of the components of this assembly is continuing. As of this date, the punch is approximately 50% completed. Completion of this die assembly is now scheduled for the early part of October.

2. First Draw Die - No. E-20001

Fabrication of this die assembly is well underway. Machining of both the punch and the die shoe has been started during this report period. Completion of this die assembly is scheduled for the end of October.

3. Second Draw Die - No. E-20002

Fabrication of all of the components of this die assembly is continuing and is now scheduled for completion the first week of November.

4. Third Draw Die - No. E-20003

The results of the survey of foundries with greater capacity and experience on pouring large castings have been reviewed. The foundries approached, and the foundry which has been selected, have national reputations for the size of castings they can produce and are recognized for their ability in the field. Several meetings have been held for the purpose of thorough discussion of the application of the punch as related to foundry technique. After careful consideration, it was agreed that a chilled casting made to the same rigid requirements as those associated with roll manufacture would be required. The foundry has assured us that such techniques can be readily utilized to produce the balance of our cold draw punches. Orders for these castings are being released.

Fabrication of the balance of the components of the third draw die assembly is well underway.

5. Fourth Draw Die - No. E-20004

(a) Competitive bids were obtained and orders were placed for the material required for this die assembly.

(b) Requests for bids for the fabrication of this die assembly have been issued.

6. Fifth Draw Die - No. E-20005

(a) Competitive bids were obtained and orders were placed for the material required for this die assembly.

7. Sixth Draw Die - No. E-20006

(a) Competitive bids were obtained and orders were placed for the material required for this die assembly.

(b) Requests for bids for the fabrication of this die assembly have been issued.

III Alloy Investigation

(A) Strain Hardening Tests

In a prior report, the results of tests to determine the strain hardening characteristics of the 20% and 25% nickel alloys and the all beta titanium alloy have been presented. Before presenting the results of metallographic examination of the test samples, a brief review of the strain hardening test method will be presented.

There are various methods by which an alloy may be tested to determine its strain hardening characteristics. Due to the simplicity and low cost of two small flattening die sections, the compression method was chosen as a means of establishing the curve and to become more familiar with the deformation characteristics of the alloy. During the test a small cyclinder, 0.800" diameter by 0.820" high, was compressed with a load of 8 tons and measured for compressed height and diameter. A second sample of the same size was then compressed with a load of 16 tons and measurements made.

This sequence was continued in 8 ton increments until the capacity of the testing machine (144 tons) was reached. The percentage of reduction in height was then plotted against compressive stress which was based upon the compressed area of the test sample. These results and the variation in hardness with increasing reduction have been presented in General Report No. 6.

(B) Results of Metallographic Studies

1. A metallographic examination was made of each specimen tested in establishing the strain hardening curves but photomicrographs were recorded of only a few of the reduction stages to illustrate the effects of deformation on the structure. There was no evidence of micro-cracks in any of the samples examined.

2. 20% Nickel Alloy

The following photomicrographs, negative numbers A-58 through A-67, illustrate the effect of the designated amounts of deformation on the microstructure of the alloy.

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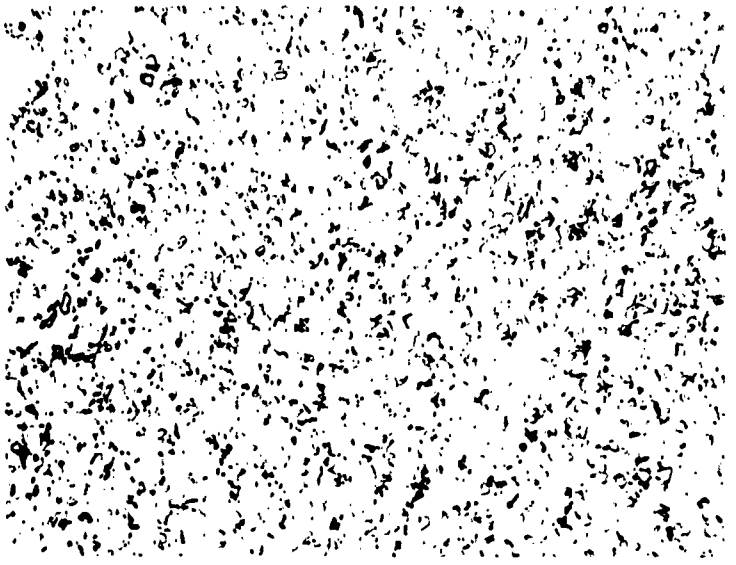

Mag: X100 Etchant: Nital & Picral

Neg. No. A-58

Material: 20% Nickel Alloy
Condition: As annealed - No deformation
Hardness: Rockwell "C" Scale 30.0

Mag: X500 Etchant: Nital & Picral

Neg. No. A-59

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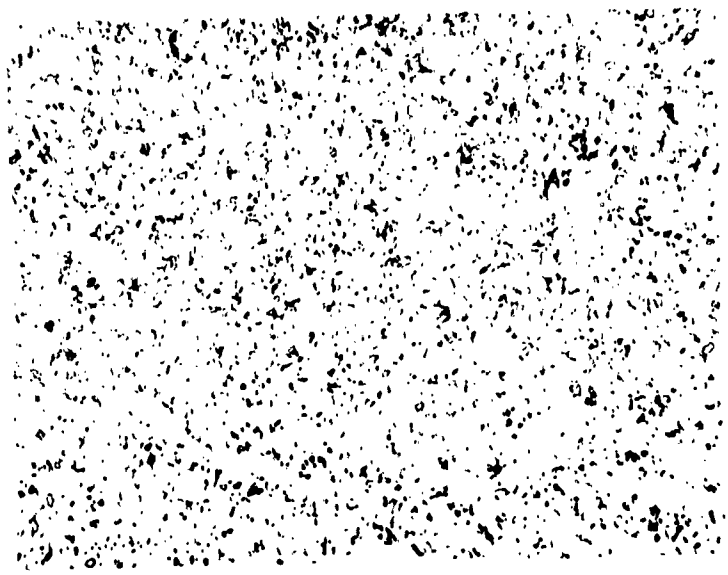
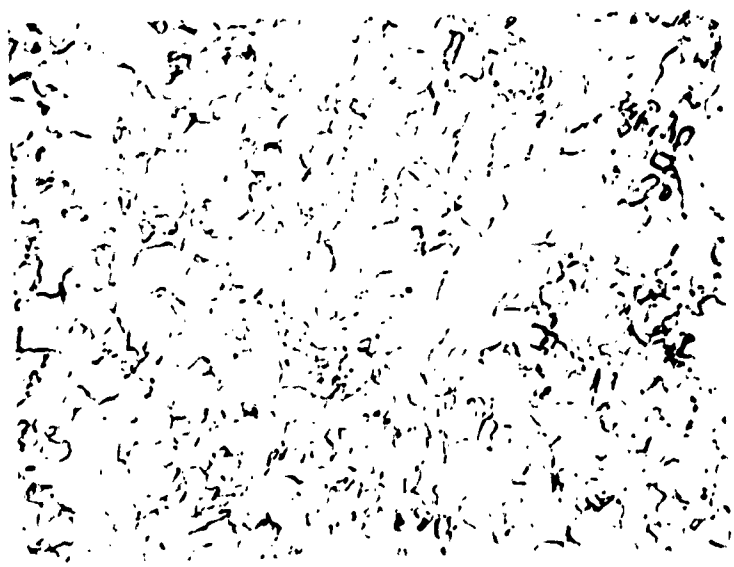


Mag: X100 Etchant: Nital & Picral
Neg. No. A-60

Material: 20% Nickel Alloy
Condition: Cold compressed 14.6% in single reduction
Hardness: Rockwell "C" Scale 31.8



Mag: X500 Etchant: Nital & Picral
Neg. No. A-61

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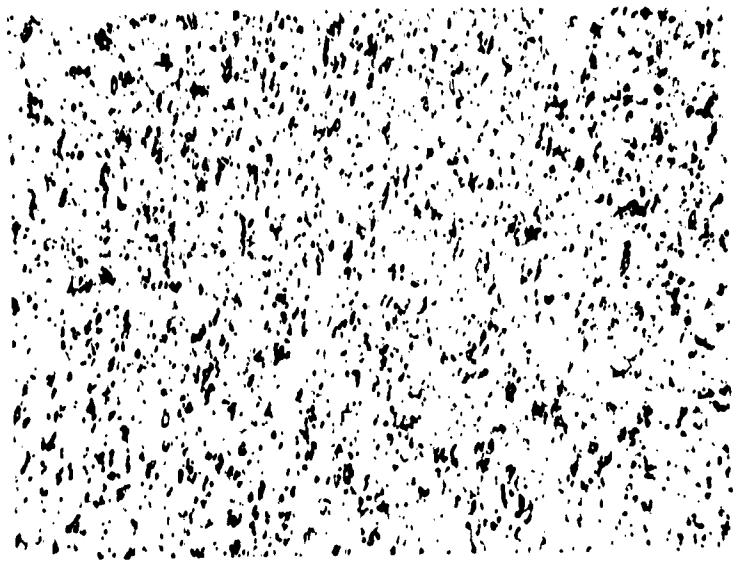
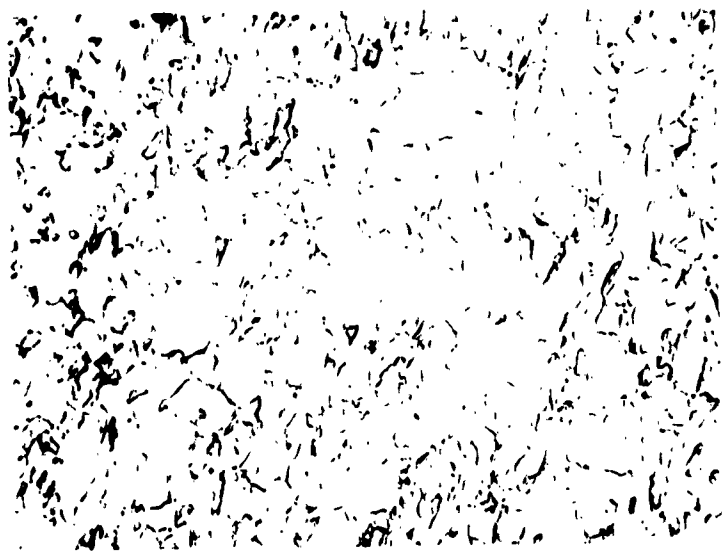


Mag: X100 Etchant: Nital & Picral

Neg. No. A-62

Material: 20% Nickel Alloy
Condition: Cold Compressed 33.4% in single reduction
Hardness: Rockwell "C" Scale 32.8



Mag: X500 Etchant: Nital & Picral

Neg. No. A-63

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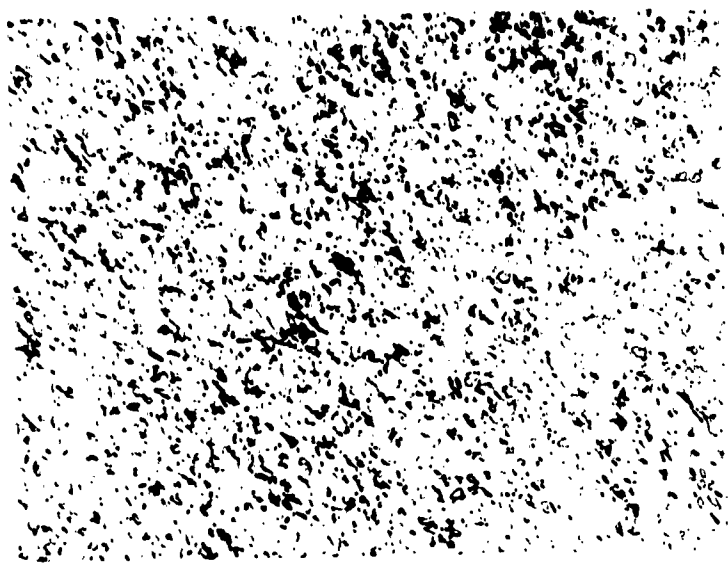
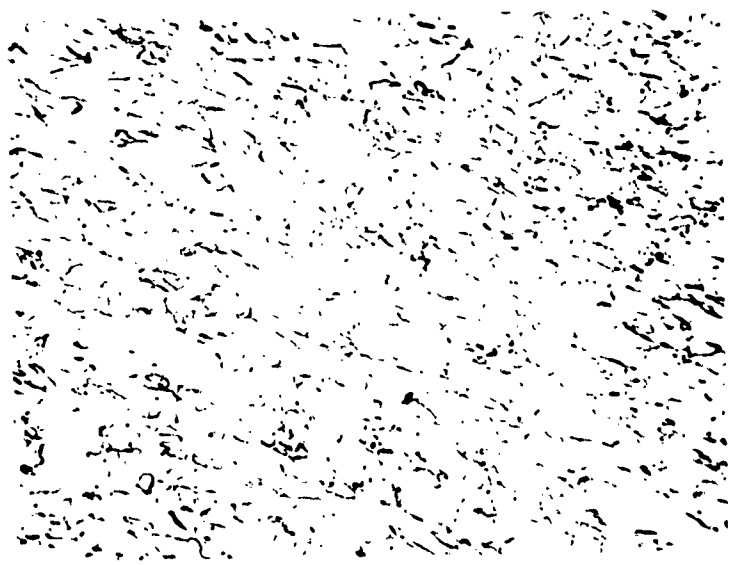


Mag: X100 Etchant: Nital & Picral

Neg. No. A-64

Material: 20% Nickel Alloy
Condition: Cold Compressed 49.0% in single reduction
Hardness: Rockwell "C" Scale 34.1



Mag: X500 Etchant: Nital & Picral

Neg. No. A-65

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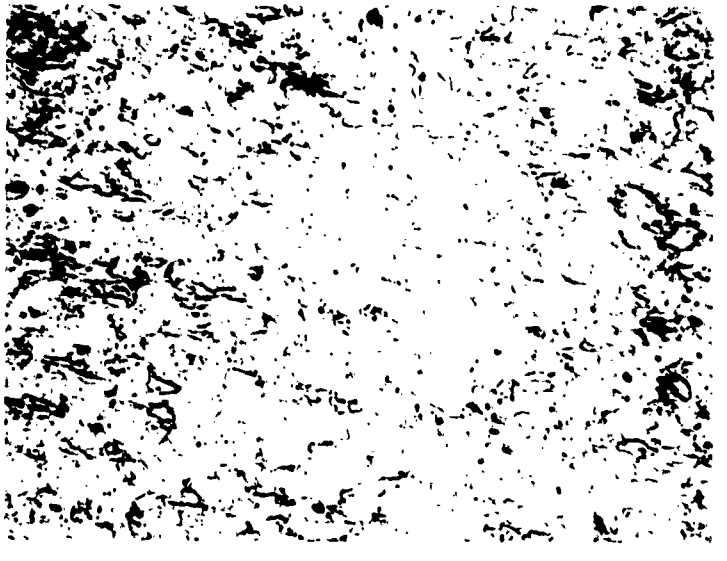
Mag: X100 Etchant: Nital & Picral

Neg. No. A-66

Material: 20% Nickel Alloy

Condition: Cold compressed 57.1% in single reduction

Hardness: Rockwell "C" Scale 34.3



Mag: X500 Etchant: Nital & Picral

Neg. No. A-67

3. 25% Nickel Alloy

The following photomicrographs, negative numbers A-69 through A-78 inclusive, illustrate the effect of the designated amounts of deformation on the microstructure of the alloy.

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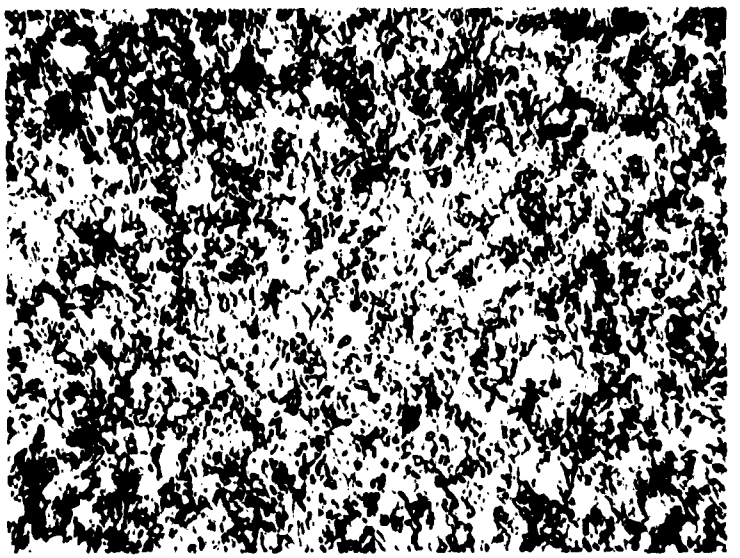

Mag: X100 Etchant: Nital & Picral

Neg. No. A-69

Material: 25% Nickel Alloy
Condition: As Annealed - No deformation
Hardness: Rockwell "B" Scale 93.5

Mag: X500 Etchant: Nital & Picral

Neg. No. A-70

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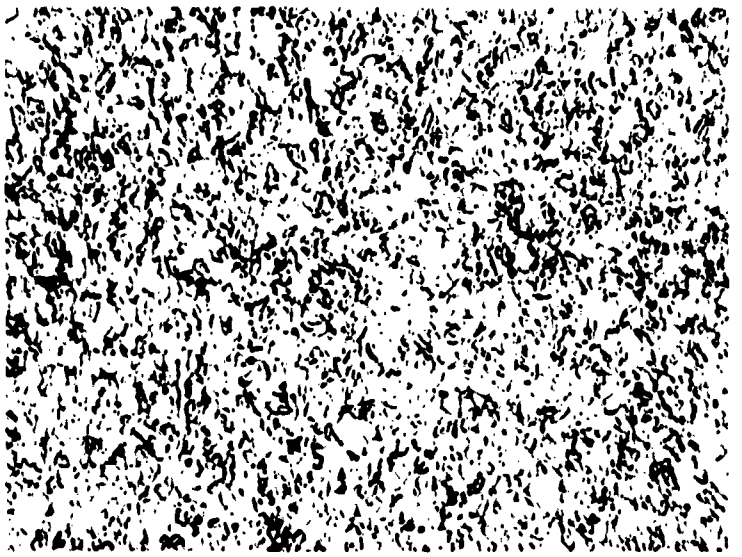
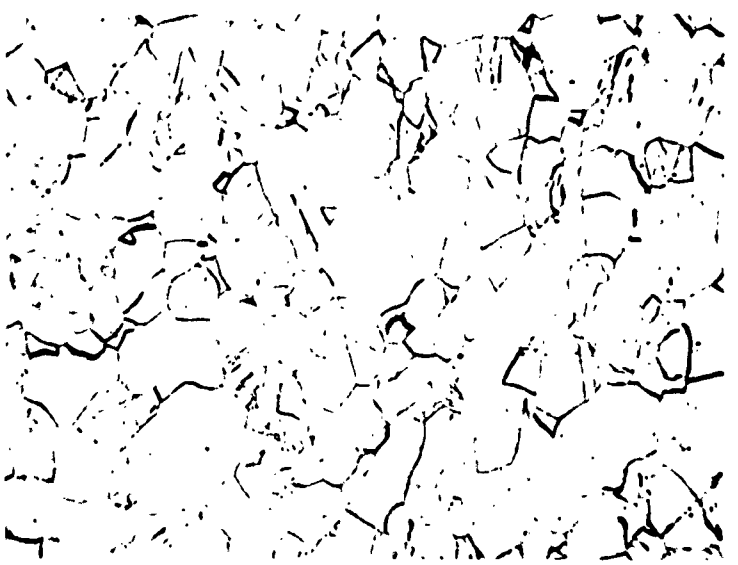


Mag: X100 Etchant: Nital & Picral
Neg. No. A-71

Material: 25% Nickel Alloy
Condition: Cold Compressed 16.6% in single reduction
Hardness: Rockwell "B" Scale 31.5



Mag: X500 Etchant: Nital & Picral
Neg. No. A-72

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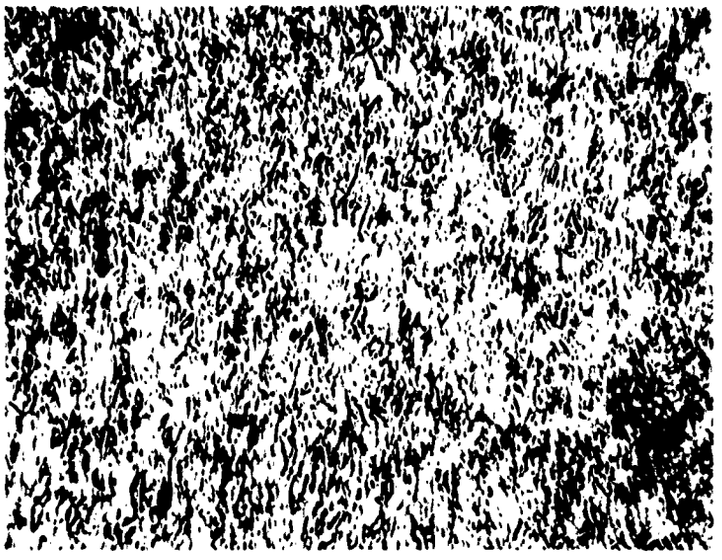
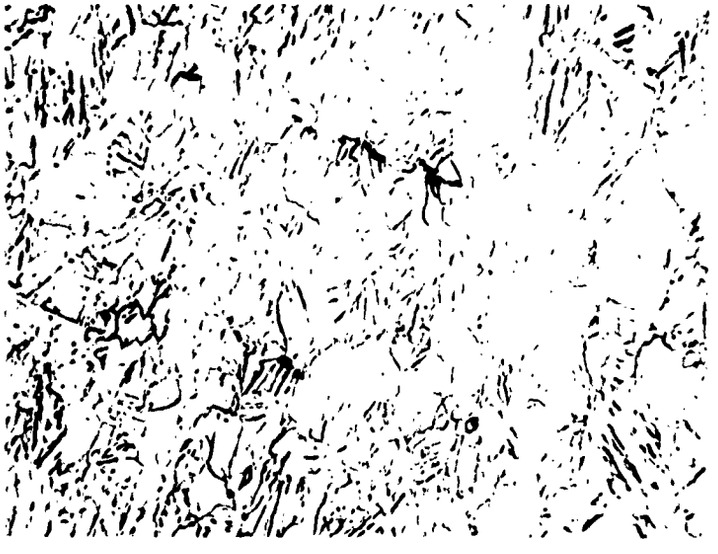


Mag: X100 Etchant: Nital & Picral
Neg. No. A-73
Material: 25% Nickel Alloy
Condition: Cold compressed 29.7% in single reduction
Hardness: Rockwell "C" Scale 33.0



Mag: X500 Etchant: Nital & Picral
Neg. No. A-74

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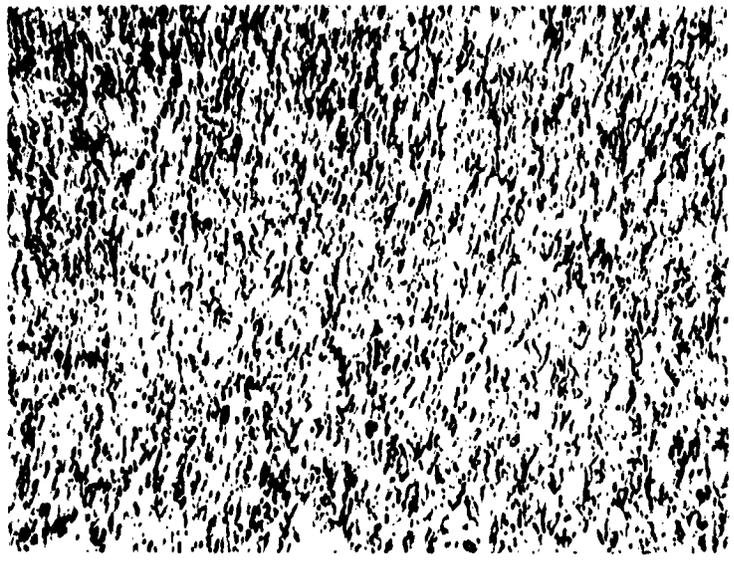

Mag: X100 Etchant: Nital & Picral

Neg. No. A-75

Material: 25% Nickel Alloy
Condition: Cold compressed 48.4% in single reduction
Hardness: Rockwell "C" Scale 34.5

Mag: X500 Etchant: Nital & Picral

Neg. No. A-76

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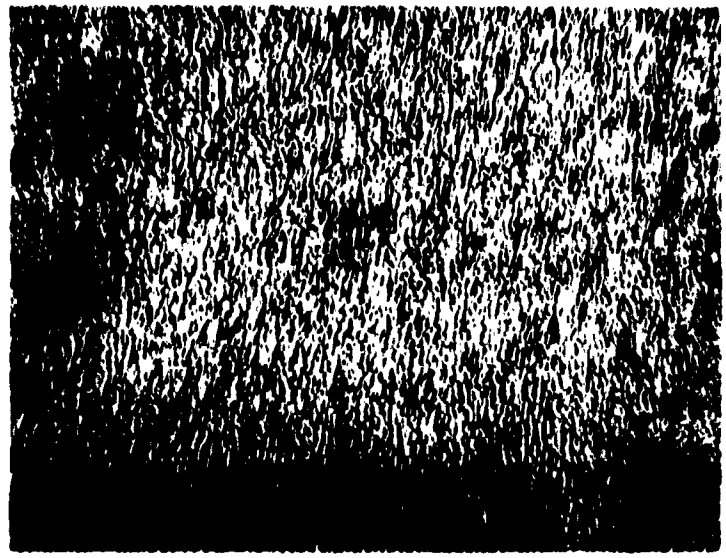

Mag: X100 Etchant: Nital & Picral
Neg. No. A-77

Material: 25% Nickel Alloy
Condition: Cold compressed 57.9% in single reduction
Hardness: Rockwell "C" Scale 34.5

Mag: X500 Etchant: Nital & Picral
Neg. No. A-78

4. All Beta Titanium Alloy

The following photomicrographs, negative numbers A-80 through A-93, illustrate the effect of the designated amounts of deformation on the microstructure of the alloy.

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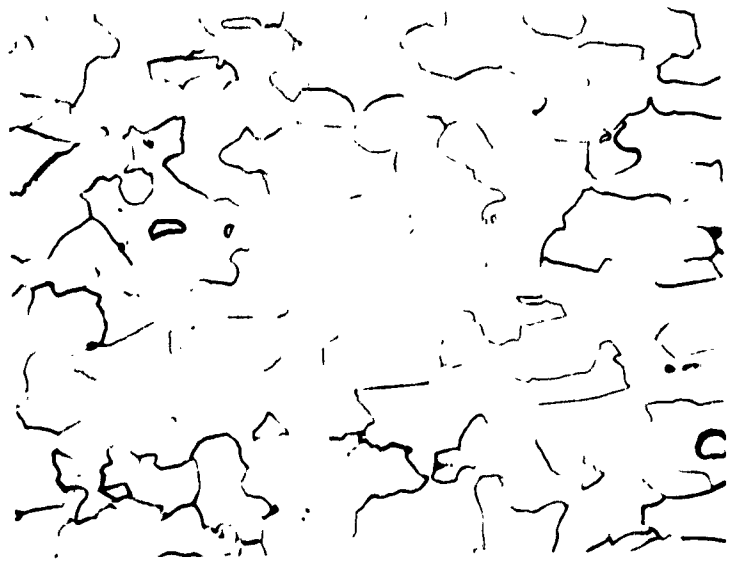

Mag: X100 Etchant: Kroll's Reagent

Neg. No. A-80

Material: All beta titanium alloy
Condition: As annealed - No deformation
Hardness: Rockwell "C" Scale 29.5

Mag: X500 Etchant: Kroll's Reagent

Neg. No. A-82

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Mag: X100 Etchant: Kroll's Reagent
Neg. No. A-83

Material: All beta titanium alloy
Condition: Cold compressed 11.8% in single reduction
Hardness: Rockwell "C" Scale 33.9

Mag: X500 Etchant: Kroll's Reagent
Neg. No. A-84

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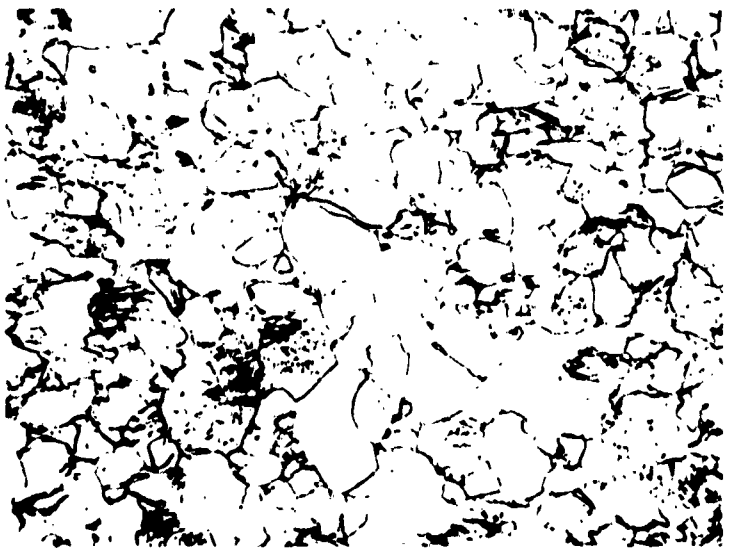
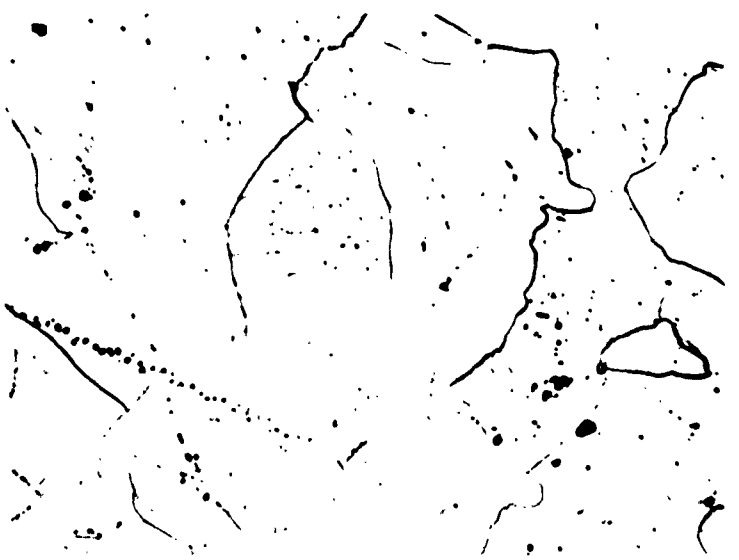


Mag: X100 Etchant: Kroll's Reagent

Neg. No. A-85

Material: All beta titanium alloy
Condition: Cold compressed 24.4% in single reduction
Hardness: Rockwell "C" Scale 36.5



Mag: X500 Etchant: Kroll's Reagent

Neg. No. A-86

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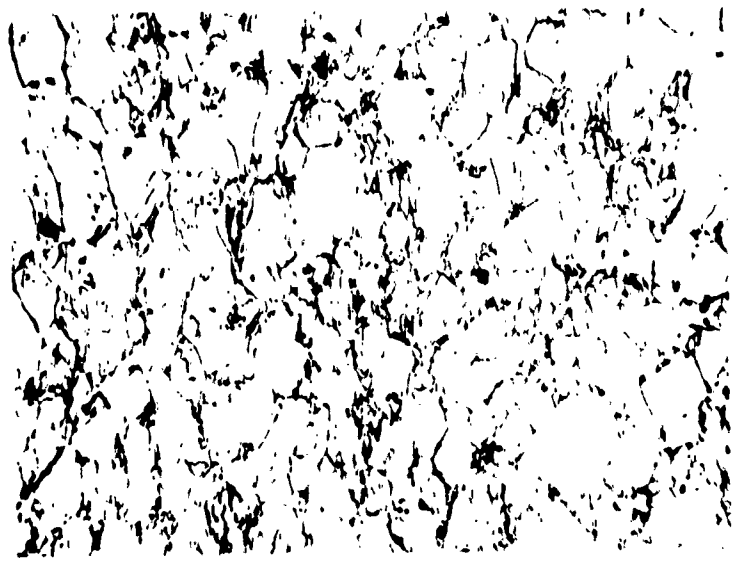

Mag: X100 Etchant: Kroll's Reagent

Neg. No. A-87

Material: All beta titanium alloy
Condition: Cold compressed 37.8% in single reduction
Hardness: Rockwell "C" Scale 40.0

Mag: X500 Etchant: Kroll's Reagent

Neg. No. A-88

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Mag: X100 Etchant: Kroll's Reagent
Neg. No. A-89

Material: All beta titanium alloy
Condition: Cold compressed 50.2% in single reduction
Hardness: Rockwell "C" Scale 40.5

Mag: X500 Etchant: Kroll's Reagent
Neg. No. A-90

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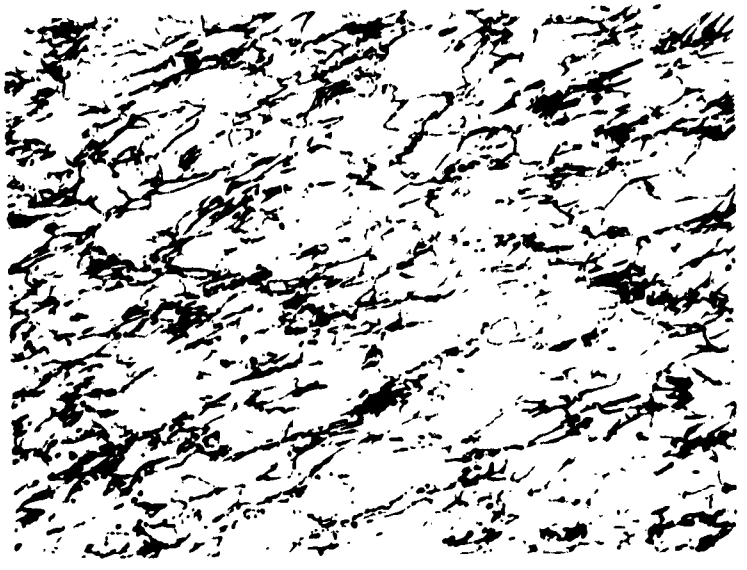

Mag: X100 Etchant: Kroll's Reagent

Neg. No. A-91

Material: All beta titanium alloy
Condition: Cold compressed 56.6% in single reduction
Hardness: Rockwell "C" Scale 40

Mag: X500 Etchant: Kroll's Reagent

Neg. No. A-93

5. The above data indicate that all three materials possess a high degree of ductility in compression. Although reductions in excess of 50% are possible in compression, this does not mean that a 50% reduction is possible during deep drawing or any other forming method which involves tensile loading. The degree of ductility exhibited by the materials, however, indicates that all three should be capable of normal reductions when deep drawn cold. The increase over 300-M in compressive stress for a given reduction indicates that more tonnage will be required to draw the 20% and 25% nickel alloys and the all beta titanium.

(B) Sub-scale Drawing Tests

The second draw punch of the two inch diameter tooling has been released for modification. As soon as this modification is completed, the sub-scale cups of the 20% nickel alloy will be given their second cold draw.

Small billets of the all beta titanium alloy are currently being prepared from three inch round bar stock. These billets will then be hot pancaked, machined, and submitted to sub-scale drawing tests.

A procurement specification has been written for full-size forged billet blocks of the 20% nickel alloy and invitations for bids have been released.

In our next report, a chart will be included that will reflect our development and die tryout schedule. Our development personnel will be divided into three crews for around-the-clock operation to expedite the tryout of the full-size special tooling. We are planning on hydrotesting the Phase I configuration by the first part of March and the Phase II configuration by June.

Sincerely yours,

LYON INCORPORATED

Wayne A. Martin

Wayne A. Martin, Director
Lyon Ord. Res. and Mfg.

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